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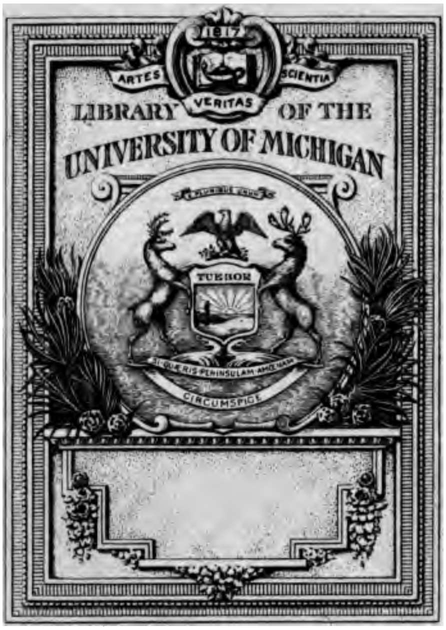
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TO any work on Philoſophy which bears the name of BENJAMIN FRANKLIN, eulogium is unneceſſary. It will ſuffice therefore to ſay, the following ſheets were penned by that great Philoſopher, and make part of the publiſhed Tranſactions of the American Philoſophical Society.

The ſubject is one which claims particular attention in England, where, from the accuſtomed mode of warming rooms, ſmoke is liable to be very obnoxious to perſons, and detrimental to furniture. The means to preſerve the one, and to augment the comforts of the other, are clearly pointed out in the following Eſſay, which may be conſidered as divided into two parts: the firſt contains an enquiry into the cauſes of ſmoky chimneys; the ſecond points out the remedies. To ſpread therefore the knowledge which theſe ſheets contain, will it is hoped be conſidered as rendering a ſervice to the community in general.

To theſe reaſonings on the cauſes and cure of ſmoky chimneys are ſubjoined, by the ſame able hand, conſiderations and experiments on ſtoves or fire-places; in which will be found many valuable obſervations and hints for the œconomical management of fuel; an article in general coſtly, but particularly ſo in this metropolis.

LONDON, 1793.

OBSERVATIONS

ON

SMOKY CHIMNEYS.

A Letter from Dr. B. FRANKLIN *to Dr.* INGENHAUSZ, *Phyſician to the Emperor, at Vienna.*

At Sea, Auguſt 28th, 1785.

Dear Friend,

IN one of your letters, a little before I left France, you deſire me to give you in writing my thoughts upon the conſtruction and uſe of chimneys, a ſubject you had ſometimes heard me touch upon in converſation. I embrace willingly this leiſure afforded by my preſent ſituation to comply with your requeſt, as it will not only ſhew my regard to the deſires of a friend, but may at the ſame time be of ſome utility to others, the doctrine of chimneys appearing not to be as yet generally well underſtood, and miſtakes reſpecting them being attended with conſtant inconvenience, if not remedied, and with fruitleſs expence, if the true remedies are miſtaken.

Thoſe who would be acquainted with this ſubject ſhould begin by conſidering on what principle ſmoke aſcends in any chimney. At firſt many are apt to think, that ſmoke is in its nature and of itſelf ſpecifically lighter than air, and riſes in it for the ſame reaſon that cork riſes in water. Theſe ſee no cauſe why ſmoke ſhould not riſe in the chimney, though the room be ever ſo cloſe. Others think there is a power in chimneys to *draw* up the ſmoke, and that there are different forms of chimneys which afford more or leſs of this power. Theſe amuſe themſelves with ſearching for the beſt form. The equal dimenſions of a funnel in its whole length is not thought artificial enough; and it is made, for fancied reaſons, ſometimes tapering and narrowing from below upwards, and ſometimes the contrary, &c. &c. A ſimple experiment or two may ſerve to give more correct ideas. Having lit a pipe of tobacco, plunge the ſtem to the bottom of a decanter half filled with cold water; then putting a rag over the bowl, blow through it, and make the ſmoke deſcend in the ſtem of the pipe, from the end of which it will riſe in bubbles through the water; and being thus cooled, will not afterwards riſe to go out through the neck of the decanter, but remain ſpreading itſelf and reſting

ing on the ſurface of the water. This ſhows that ſmoke is really heavier than air, and that it is carried upwards only when attached to, or acted upon by air that is heated, and thereby rarefied and rendered ſpecifically lighter than the air in its neighbourhood.

Smoke being rarely ſeen but in company with heated air, and its upward motion being viſible, though that of the rarefied air that drives it is not ſo, has naturally given riſe to the error.

I need not explain to you, my learned friend, what is meant by rarefied air; but if you make the public uſe you propoſe of this letter, it may fall into the hands of ſome who are unacquainted with the term and with the thing. Theſe then may be told, that air is a fluid which has weight as well as others, though about eight hundred times lighter than water. That heat makes the particles of air recede from each other and take up more ſpace, ſo that the ſame weight of air heated will have more bulk than equal weights of cold air which may ſurround it, and in that caſe muſt riſe, being forced upwards by ſuch colder and heavier air, which preſſes to get under it and take its place. That air is ſo rarefied or expanded by heat, may be proved to their comprehenſion by a lank-blown bladder, which laid before a fire will ſoon ſwell, grow tight, and burſt.

Another experiment may be to take a glaſs tube about an inch in diameter, and twelve inches long, open at both ends, and fixed upright on legs ſo that it need not be handled, for the hands might warm it. At the end of a quill faſten five or ſix inches of the fineſt light filament of ſilk, ſo that it may be held either above the upper end of the tube, or under the lower end, your warm hand being at a diſtance by the length of the quill. If there were any motion of air through the tube, it would manifeſt itſelf by its effect on the ſilk*; but if the tube and the air in it are of the ſame temperature with the ſurrounding air, there will be no ſuch motion, whatever may be the form of the tube, whether crooked or ſtraight, narrow below and winding upwards, or the contrary; the air in it will be quieſcent. Warm the tube, and you will find, as long as it continues warm, a conſtant current of air entering below and paſſing up through it, till diſcharged at the top; becauſe the warmth of the tube being communicated to the air it contains, rarefies that air, and makes it lighter than the air without, which therefore preſſes in below, forces it upwards, follows and takes its place, and is rarefied in its turn. And, without warming the tube, if you hold under it a knob of hot iron, the air thereby heated will riſe and fill the tube, going out at its top; and this motion in the tube will continue as long as the knob remains hot, becauſe the air entering the tube below is heated and rarefied by paſſing near and over that knob.

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* Plate I. Fig. 1.

That this motion is produced merely by the difference of ſpecific gravity between the fluid within and that without the tube, and not by any fancied form of the tube itſelf, may appear by plunging it into water contained in a glaſs jar a foot deep, through which ſuch motion might be ſeen. The water within and without the tube being of the ſame ſpecific gravity, balance each other, and both remain at reſt. But take out the tube, ſtop its bottom with a finger, and fill it with olive oil, which is lighter than water, then ſtopping the top, place it as before, its lower end under water, its top a very little above. As long as you keep the bottom ſtopt, the fluids remain at reſt; but the moment it is unſtopt, the heavier enters below, forces up the lighter, and takes its place. And the motion then ceaſes, merely becauſe the new fluid cannot be ſucceſſively made lighter, as air may be by a warm tube.

In fact, no form of the funnel of a chimney has any ſhare in its operation or effect reſpecting ſmoke, except its height. The longer the funnel, if erect, the greater its force, when filled with heated and rarefied air, to *draw* in below and drive up the ſmoke, if one may, in compliance with cuſtom, uſe the expreſſion *draw*, when in fact it is the ſuperior weight of the ſurrounding atmoſphere that *preſſes* to enter the funnel below, and ſo *drives up* before it the ſmoke and warm air it meets with in its paſſage.

I have been the more particular in explaining theſe firſt principles, becauſe, for want of clear ideas reſpecting them, much fruitleſs expence has been occaſioned; not only ſingle chimneys, but, in ſome inſtances within my knowledge, whole ſtacks having been pulled down, and rebuilt with funnels of different forms, imagined more powerful in *drawing* ſmoke; but, having ſtill the ſame height and the ſame opening below, have performed no better than their predeceſſors.

What is it then which makes a *ſmoky chimney*; that is, a chimney which, inſtead of conveying up all the ſmoke, diſcharges a part of it into the room, offending the eyes, and damaging the furniture?

The cauſes of this effect, which have fallen under my obſervation, amount to *nine*, differing from each other, and therefore requiring different remedies.

1. *Smoky chimneys, in a new houſe, are ſuch frequently from mere want of air.* The workmanſhip of the rooms being all good, and juſt out of the workman's hand, the joints of the boards of the flooring, and of the pannels of wainſcotting, are all true and tight, the more ſo as the walls, perhaps not yet thoroughly dry, preſerve a dampneſs in the air of the room

which keeps the wood-work ſwelled and cloſe. The doors and the ſaſhes too, being worked with truth, ſhut with exactneſs, ſo that the room is as tight as a ſnuff-box, no paſſage being left open for air to enter, except the key-hole, and even that is ſometimes covered by a little dropping ſhutter. Now, if ſmoke cannot riſe but as connected with rarefied air, and a column of ſuch air, ſuppoſe it filling the funnel, cannot riſe, unleſs other air be admitted to ſupply its place; and if, therefore, no current of air enter the opening of the chimney, there is nothing to prevent the ſmoke coming out into the room. If the motion upwards of the air in a chimney that is freely ſupplied, be obſerved by the riſing of the ſmoke, or a feather in it, and it be conſidered that in the time ſuch feather takes in riſing from the fire to the top of a chimney, a column of air equal to the content of the funnel muſt be diſcharged, and an equal quantity ſupplied from the room below, it will appear abſolutely impoſſible that this operation ſhould go on if the tight room is kept ſhut; for were there any force capable of drawing conſtantly ſo much air out of it, it muſt ſoon be exhauſted like the receiver of an air-pump, and no animal could live in it. Thoſe therefore who ſtop every crevice in a room to prevent the admiſſion of freſh air, and yet would have their chimney carry up the ſmoke, require inconſiſtencies, and expect impoſſibilities. Yet, under this ſituation, I have ſeen the owner of a new houſe, in deſpair, and ready to ſell it for much leſs than it coſt, conceiving it uninhabitable, becauſe not a chimney in any one of its rooms would carry off the ſmoke, unleſs a door or window were left open. Much expence has alſo been made, to alter and amend new chimneys which had really no fault; in one houſe particularly that I knew, of a nobleman in Weſtminſter, that expence amounted to no leſs than three hundred pounds, *after* his houſe had been, as he thought, finiſhed, and all charges paid. And, after all, ſeveral of the alterations were ineffectual, for want of underſtanding the true principles.

Remedies. When you find, on trial, that opening the door or a window enables the chimney to carry up all the ſmoke, you may be ſure that want of air *from without* was the cauſe of its ſmoking: I ſay *from without*, to guard you againſt a common miſtake of thoſe who may tell you, the room is large, contains abundance of air, ſufficient to ſupply any chimney, and therefore it cannot be that the chimney wants air. Theſe reaſoners are ignorant, that the largeneſs of a room, if tight, is in this caſe of ſmall importance, ſince it cannot part with a chimney full of its air without occaſioning ſo much vacuum; which it requires a great force to effect, and could not be borne if effected.

It appearing plainly, then, that ſome of the outward air muſt be admitted, the queſtion will be, how much is *abſolutely neceſſary?* for you would avoid admitting more, as being contrary to one of your intentions in having a fire, viz. that of warming your room. To diſcover this quantity, ſhut the door gradually while a middling fire is burning, till you find that, before it is quite ſhut, the ſmoke begins to come out into the room; then open it a little, till you perceive the ſmoke comes out no longer. There hold the door, and obſerve the width of the open crevice between the edge of the door and the rabbit it ſhould ſhut into. Suppoſe the diſtance to be half an inch, and the door eight feet high, you find thence that your room requires an entrance for air equal in area to ninety-ſix half inches, or forty-eight ſquare inches, or a paſſage of ſix inches by eight. This however is a large ſuppoſition, there being few chimneys that, having a moderate opening and a tolerable height of funnel, will not be ſatisfied with ſuch a crevice of a quarter of an inch; and I have found a ſquare of ſix by ſix, or thirty-ſix ſquare inches, to be a pretty good medium, that will ſerve for moſt chimneys. High funnels, with ſmall and low openings, may indeed be ſupplied through a leſs ſpace, becauſe, for reaſons that will appear hereafter, the *force of levity*, if one may ſo ſpeak, being greater in ſuch funnels, the cool air enters the room with greater velocity, and conſequently more enters in the ſame time. This however has its limits; for experience ſhews, that no increaſed velocity ſo occaſioned, has made the admiſſion of air through the key-hole equal in quantity to that through an open door, though through the door the current moves ſlowly, and through the key-hole with great rapidity.

It remains then to be conſidered how and where this neceſſary quantity of air from without is to be admitted ſo as to be leaſt inconvenient. For if at the door left ſo much open, the air thence proceeds directly to the chimney, and in its way comes cold to your back and heels as you ſit before your fire. If you keep the door ſhut, and raiſe a little the ſaſh of your window, you feel the ſame inconvenience. Various have been the contrivances to avoid this; ſuch as bringing in freſh air through pipes in the jams of the chimney, which pointing upwards ſhould blow the ſmoke up the funnel; opening paſſages into the funnel above, to let in air for the ſame purpoſe. But theſe produce an effect contrary to that intended: for as it is the conſtant current of air paſſing from the room *through the opening of the chimney* into the funnel, which prevents the ſmoke coming out into the room, if you ſupply the funnel by other means or in other ways with the air it wants, and eſpecially if that air be cold, you diminiſh the force of that current, and the ſmoke, in its efforts to enter the room, finds leſs reſiſtance.

The wanted air muſt then *indiſpenſably* be admitted into the room, to ſupply what goes off through the opening of the chimney. M. Gauger, a very ingenious and intelligent French writer on the ſubject, propoſes with judgment to admit it *above* the opening of the chimney; and to prevent inconvenience from its coldneſs, he directs its being made to paſs in its entrance through winding cavities made behind the iron back and ſides of the fire-place, and under the iron hearth-plate; in which cavities it will be warmed, and even heated, ſo as to contribute much, inſtead of cooling, to the warming of the room. This invention is excellent in itſelf, and may be uſed with advantage in building new houſes; becauſe the chimneys may then be ſo diſpoſed, as to admit conveniently the cold air to enter ſuch paſſages: but in houſes built without ſuch views, the chimneys are often ſo ſituated, as not to afford that convenience without great and expenſive alterations. Eaſy and cheap methods, though not quite ſo perfect in themſelves, are of more general utility; and ſuch are the following.

In all rooms where there is a fire, the body of air warmed and rarefied before the chimney is continually changing place, and making room for other air that is to be warmed in its turn. Part of it enters and goes up the chimney, and the reſt riſes and takes place near the ceiling. If the room be lofty, that warm air remains above our heads as long as it continues warm, and we are little benefited by it, becauſe it does not deſcend till it is cooler. Few can imagine the difference of climate between the upper and lower parts of ſuch a room, who have not tried it by the thermometer, or by going up a ladder till their heads are near the ceiling. It is then among this warm air that the wanted quantity of outward air is beſt admitted, with which being mixed, its coldneſs is abated, and its inconvenience diminiſhed, ſo as to become ſcarce obſervable. This may be eaſily done, by drawing down about an inch the upper ſaſh of a window; or, if not moveable, by cutting ſuch a crevice through its frame; in both which caſes, it will be well to place a thin ſhelf of the length, to conceal the opening, and ſloping upwards to direct the entering air horizontally along and under the ceiling. In ſome houſes the air may be admitted by ſuch a crevice made in the wainſcot, cornice, or plaſtering, near the ceiling, and over the opening of the chimney. This, if practicable, is to be choſen, becauſe the entering cold air will there meet with the warmeſt riſing air from before the fire, and be ſooneſt tempered by the mixture: the ſame kind of ſhelf ſhould alſo be placed here. Another way, and not a very difficult one, is to take out an upper pane of glaſs in one of your ſaſhes, ſet it in a tin frame, giving it two ſpringing angular ſides, and then replacing it, with hinges below on which it may be turned to open more or leſs above*. It will then have the appearance of an internal ſky-light. By drawing this pane in, more or leſs, you may admit what air you find neceſſary. Its poſition will naturally throw that air up and along the ceiling. This is what is called in France a *Was iſt das?* As this is a German queſtion, the invention is probably of that nation, and takes its name from the frequent aſking of that queſtion when it firſt appeared. In England, ſome have of late years cut a round hole about five inches diameter in a pane of the ſaſh, and placed againſt it a circular plate of tin hung on an axis, and cut into vanes, which being ſeparately bent a little obliquely, are acted upon by the entering air, ſo as to force the plate continually round like the vanes of a windmill. This admits the outward air, and by the continual whirling of the vanes, does in ſome degree diſperſe it. The noiſe only is a little inconvenient.

2. A ſecond cauſe of the ſmoking of chimneys is, *their openings in the room being too large*; that is, too wide, too high, or both. Architects in general have no other ideas of proportion in the opening of a chimney, than what relate to ſymmetry and beauty, reſpecting the dimenſions of the room†; while its

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* Plate I. Figure 2.

† See Appendix, No. I.

true proportion, reſpecting its function and utility, depends on quite other principles; and they might as properly proportion the ſtep in a ſtaircaſe to the height of the ſtory, inſtead of the natural elevation of men's legs in mounting. The proportion then to be regarded, is what relates to the height of the funnel: for as the funnels in the different ſtories of a houſe are neceſſarily of different heights or lengths, that from the loweſt floor being the higheſt or longeſt, and thoſe of the other floors ſhorter and ſhorter, till we come to thoſe in the garrets, which are of courſe the ſhorteſt; and the force of draught being, as already ſaid, in proportion to the height of funnel filled with rarefied air; and a current of air from the room into the chimney, ſufficient to fill the opening, being neceſſary to oppoſe and prevent the ſmoke coming out into the room; it follows that the openings of the longeſt funnels may be larger, and that thoſe of the ſhorter funnels ſhould be ſmaller: for if there be a large opening to a chimney that does not draw ſtrongly, the funnel may happen to be furniſhed with the air it demands by a partial current entering on one ſide of the opening, and, leaving the other ſide free of any oppoſing current, may permit the ſmoke to iſſue there into the room. Much too of the force of draught in a funnel depends on the degree of rarefaction in the air it contains, and that depends on the nearneſs to the fire of its paſſage in entering the funnel. If it can enter far from the fire on each ſide, or far above the fire in a wide or high opening, it receives little heat in paſſing by the fire, and the contents of the funnel is by that means leſs different in levity from the ſurrounding atmoſphere, and its force in drawing conſequently weaker. Hence, if too large an opening be given to chimneys in upper rooms, thoſe rooms will be ſmoky: on the other hand, if too ſmall openings be given to chimneys in the lower rooms, the entering air operating too directly and violently on the fire, and afterwards ſtrengthening the draught as it aſcends the funnel, will conſume the fuel too rapidly.

Remedy. As different circumſtances frequently mix themſelves in theſe matters, it is difficult to give preciſe dimenſions for the openings of all chimneys. Our fathers made them generally much too large; we have leſſened them; but they are often ſtill of greater dimenſion than they ſhould be, the human eye not being eaſily reconciled to ſudden and great changes. If you ſuſpect that your chimney ſmokes from the too great dimenſion of its opening, contract it by placing moveable boards ſo as to lower and narrow it gradually, till you find the ſmoke no longer iſſues into the room. The proportion ſo found will be that which is proper for that chimney, and you may employ the bricklayer or maſon to reduce it accordingly. However, as, in building new houſes, ſomething muſt be ſometimes hazarded, I would

I would make the openings in my lower rooms about thirty inches ſquare and eighteen deep; and thoſe in the upper, only eighteen inches ſquare, and not quite ſo deep; the intermediate ones diminiſhing in proportion as the height of funnel diminiſhed. In the larger openings, billets of two feet long, or half the common length of cord-wood, may be burnt conveniently; and for the ſmaller, ſuch wood may be ſawed into thirds. Where coals are the fuel, the grates will be proportioned to the openings. The ſame depth is nearly neceſſary to all, the funnels being all made of a ſize proper to admit a chimney-ſweeper. If, in large and elegant rooms, cuſtom or fancy ſhould require the appearance of a larger chimney, it may be formed of expenſive marginal decorations, in marble, &c. In time, perhaps that which is fitteſt in the nature of things may come to be thought handſomeſt. But at preſent, when men and women in different countries ſhew themſelves diſſatisfied with the forms God has given to their heads, waiſts, and feet, and pretend to ſhape them more perfectly, it is hardly to be expected that they will be content always with the beſt form of a chimney. And there are ſome, I know, ſo bigotted to the fancy of a large noble opening, that, rather than change it, they would ſubmit to have damaged furniture, ſore eyes, and ſkins almoſt ſmoked to bacon.

3. Another cauſe of ſmoky chimneys is, *too ſhort a funnel.* This happens neceſſarily in ſome caſes, as where a chimney is required in a low building; for, if the funnel be raiſed high above the roof, in order to ſtrengthen its draught, it is then in danger of being blown down, and cruſhing the roof in its fall.

Remedies. Contract the opening of the chimney, ſo as to oblige all the entering air to paſs through or very near the fire; whereby it will be more heated and rarefied, the funnel itſelf be more warmed, and its contents have more of what may be called the force of levity, ſo as to riſe ſtrongly, and maintain a good draught at the opening.

Or you may in ſome caſes, to advantage, build additional ſtories over the low building, which will ſupport a high funnel.

If the low building be uſed as a kitchen, and a contraction of the opening therefore inconvenient, a large one being neceſſary, at leaſt when there are great dinners, for the free management of ſo many cooking utenſils; in ſuch caſe I would adviſe the building of two more funnels joining to the firſt, and having three moderate openings, one to each funnel, inſtead of one large one. When there is occaſion to uſe but one, the other two may be kept ſhut by ſliding plates, hereafter to be deſcribed*; and two or all of them may be uſed together when wanted. This will indeed be an expence, but not an uſeleſs one, ſince your cooks will work with more comfort, ſee better than in a ſmoky kitchen what they are about, your victuals will be cleaner dreſſed, and not taſte of ſmoke, as is often the caſe; and to render the effect more certain, a ſtack of three funnels may be ſafely built higher above the roof than a ſingle funnel.

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* See Appendix, No. II.

The caſe of too ſhort a funnel is more general than would be imagined, and often found where one would not expect it. For it is not uncommon, in ill-contrived buildings, inſtead of having a funnel for each room or fire-place, to bend and turn the funnel of an upper room ſo as to make it enter the ſide of another funnel that comes from below. By this means the upper room funnel is made ſhort of courſe, ſince its length can only be reckoned from the place where it enters the lower room funnel; and that funnel is alſo ſhortened by all the diſtance between the entrance of the ſecond funnel and the top of the ſtack: for all that part being readily ſupplied with air through the ſecond funnel, adds no ſtrength to the draught, eſpecially as that air is cold when there is no fire in the ſecond chimney. The only eaſy remedy here is, to keep the opening ſhut of that funnel in which there is no fire.

4. Another very common cauſe of the ſmoking of chimneys is, *their overpowering one another*. For inſtance, if there be two chimneys

in one large room, and you make fires in both of them, the doors and windows cloſe ſhut, you will find that the greater and ſtronger fire ſhall overpower the weaker, and draw air down its funnel to ſupply its own demand; which air deſcending in the weaker funnel will drive down its ſmoke, and force it into the room. If, inſtead of being in one room, the two chimneys are in two different rooms, communicating by a door, the caſe is the ſame whenever that door is open. In a very tight houſe, I have known a kitchen chimney on the loweſt floor, when it had a great fire in it, overpower any other chimney in the houſe, and draw air and ſmoke into its room, as often as the door was opened communicating with the ſtaircaſe.

Remedy. Take care that every room have the means of ſupplying itſelf from without with the air its chimney may require, ſo that no one of them may be obliged to borrow from another, nor under the neceſſity of lending. A variety of theſe means have been already deſcribed.

5. Another cauſe of ſmoking is, *when the tops of chimneys are commanded by higher buildings, or by a hill*, ſo that the wind blowing over ſuch eminences, falls like water over a dam, ſometimes almoſt perpendicularly on the tops of the chimneys that lie in its way, and beats down the ſmoke contained in them.

Remedy. That commonly applied to this caſe, is a turncap made of tin or plate iron, covering the chimney above and on three ſides, open on one ſide, turning on a ſpindle, and which being guided or governed by a vane, always preſents its back to the current. This, I believe, may be generally effectual, though not certain, as there may be caſes in which it will not ſucceed. Raiſing your funnels, if practicable, ſo as their tops may be higher, or at leaſt equal with the commanding eminence, is more to be depended on. But the turning cap, being eaſier and cheaper, ſhould firſt be tried. If obliged to build in ſuch a ſituation, I would chooſe to place my doors on the ſide next the hill, and the backs of my chimneys on the furtheſt ſide; for then the column of air falling over the eminence, and of courſe preſſing on that below, and forcing it to enter the doors or *was-iſt-das*es on that ſide, would tend to balance the preſſure down the chimneys, and leave the funnels more free in the exerciſe of their functions.

6. There is another caſe of command, the reverſe of that laſt mentioned. It is where the commanding eminence is farther from the wind than the chimney commanded. To explain this a figure may be neceſſary. Suppoſe then a building, whoſe ſide *A* happens to be expoſed to the wind, and forms a kind of dam againſt its progreſs*. The air obſtructed by this

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* Plate I. Figure 3.

dam will, like water, preſs and ſearch for paſſages through it; and finding the top of the chimney *B*, below the top of the dam, it will force itſelf down that funnel, in order to get through by ſome door or window open on the other ſide of the building. And if there be a fire in ſuch chimney, its ſmoke is of courſe beat down, and fills the room.

Remedy. I know of but one, which is, to raiſe ſuch funnel higher than the roof, ſupporting it, if neceſſary, by iron bars. For a turncap in this caſe has no effect, the dammed up air preſſing down through it in whatever poſition the wind may have placed its opening.

I know a city in which many houſes are rendered ſmoky by this operation; for their kitchens being built behind, and connected by a paſſage with the houſes, and the tops of the kitchen chimneys lower than the tops of the houſes, the whole ſide of a ſtreet, when the wind blows againſt its back, forms ſuch a dam as above deſcribed; and the wind ſo obſtructed forces down thoſe kitchen chimneys (eſpecially when they have but weak fires in them) to paſs through the paſſage and houſe into the ſtreet. Kitchen chimneys ſo formed and ſituated have another inconvenience: in ſummer, if you open your upper room windows for air, a light breeze blowing over your kitchen chimney towards the houſe, though not ſtrong enough to force down its ſmoke as aforeſaid, is ſufficient to waft it into your windows, and fill the rooms with it; which, beſides the diſagreeableneſs, damages your furniture.

7. Chimneys, otherwiſe drawing well, are ſometimes made to ſmoke by *the improper and inconvenient ſituation of a door.* When the door and chimney are on the ſame ſide of the room as in the figure *, if the door *A*, being in the corner, is made to open againſt the wall, which is common, as being there, when open, more out of the way, it follows, that when the door is only opened in part, a current of air ruſhing in, paſſes along the wall into and acroſs the opening of the chimney *B*, and flirts ſome of the ſmoke out into the room. This happens more certainly when the door is ſhutting; for then the force of the current is augmented, and becomes very inconvenient to thoſe who, warming themſelves by the fire, happen to ſit in its way.

The *Remedies* are obvious and eaſy. Either put an intervening ſcreen from the wall round great part of the fire-place; or, which is perhaps preferable, ſhift the hinges of your door, ſo as it may open the other way, and, when open, throw the air along the other wall.

8. A room that has no fire in its chimney is ſometimes filled with *ſmoke, which is received at the top of its funnel, and deſcends into the room.* In a former paper † I have already ex-

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* Plate I. Figure 4.

† See Appendix, No. II.

plained the deſcending currents of air in cold funnels; it may not be amiſs however to repeat here, that funnels without fires have an effect, according to their degree of coldneſs or warmth, on the air that happens to be contained in them. The ſurrounding atmoſphere is frequently changing its temperature; but ſtacks of funnels, covered from winds and ſun by the houſe that contains them, retain a more equal temperature. If, after a warm ſeaſon, the outward air ſuddenly grows cold, the empty warm funnels begin to draw ſtrongly upward; that is, they rarefy the air contained in them, which of courſe riſes, cooler air enters below to ſupply its place, is rarefied in its turn, and riſes; and this operation continues, till the funnel grows cooler, or the outward air warmer, or both, when the motion ceaſes. On the other hand, if, after a cold ſeaſon, the outward air ſuddenly grows warm, and of courſe lighter, the air contained in the cool funnels, being heavier, deſcends into the room; and the warmer air which enters their tops, being cooled in its turn, and made heavier, continues to deſcend; and this operation goes on, till the funnels are warmed by the paſſing of warm air through them, or the air itſelf grows cooler. When the temperature of the air and of the funnels is nearly equal, the difference of warmth in the air between day and night is ſufficient to produce theſe currents, the air will begin to aſcend the funnels as the cool of the evening comes on, and this current will continue till perhaps nine or ten o'clock the next morning, when it begins to heſitate; and as the heat of the day approaches, it ſets downwards, and continues ſo till towards evening, when it again heſitates for ſome time, and then goes upwards conſtantly during the night, as before mentioned. Now when ſmoke iſſuing from the tops of neighbouring funnels paſſes over the tops of funnels which are at the time drawing downwards, as they often are in the middle part of the day, ſuch ſmoke is of neceſſity drawn into theſe funnels, and deſcends with the air into the chamber.

The *Remedy* is, to have a ſliding plate, hereafter deſcribed *, that will ſhut perfectly the offending funnel.

9. Chimneys which generally draw well, do nevertheleſs ſometimes give ſmoke into the rooms, *it being driven down by ſtrong winds paſſing over the tops of their funnels*, though not deſcending from any commanding eminence. This caſe is moſt frequent where the funnel is ſhort, and the opening turned from the wind. It is the more grievous when it happens to be a cold wind that produces the effect, becauſe when you moſt want your fire you are ſometimes obliged to extinguiſh it. To underſtand this, it may be conſidered that the riſing light air, to obtain a free iſſue from

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* See Appendix, No. II.

the funnel, muſt puſh out of its way, or oblige the air that is over it to riſe. In a time of calm, or of little wind, this is done viſibly, for we ſee the ſmoke that is brought up by that air riſe in a column above the chimney. But when a violent current of air, that is, a ſtrong wind, paſſes over the top of a chimney, its particles have received ſo much force, which keeps them in a horizontal direction, and follow each other ſo rapidly, that the riſing light air has not ſtrength ſufficient to oblige them to quit that direction, and move upwards to permit its iſſue. Add to this, that ſome of the current paſſing over that ſide of the funnel which it firſt meets with, viz. at *A*[*], having been compreſſed by the reſiſtance of the funnel, may expand itſelf over the flue, and ſtrike the interior oppoſite ſide at *B*, from whence it may be reflected downwards, and from ſide to ſide, in the direction of the pricked lines *c c c*.

Remedies. In ſome places, particularly in Venice, where they have not ſtacks of chimneys, but ſingle flues, the cuſtom is to open or widen the top of the flue, rounding in the true form of a funnel[†]; which ſome think may prevent the effect juſt mentioned, for that the wind blowing over one of the edges into the funnel may be ſlanted out again on the other ſide by its form. I have had no experience of this;

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[*] Plate I. Figure 5.

[†] Plate I. Figure 6.

but I have lived in a windy country, where the contrary is practiſed, the tops of the flues being *narrowed* inwards, ſo as to form a ſlit for the iſſue of the ſmoke, long as the breadth of the funnel, and only four inches wide. This ſeems to have been contrived on a ſuppoſition that the entry of the wind would thereby be obſtructed; and perhaps it might have been imagined, that the whole force of the riſing warm air being condenſed, as it were, in the narrow opening, would thereby be ſtrengthened, ſo as to overcome the reſiſtance of the wind. This however did not always ſucceed; for when the wind was at north-eaſt, and blew freſh, the ſmoke was forced down by fits into the room I commonly ſat in, ſo as to oblige me to ſhift the fire into another. The poſition of the ſlit of this funnel was indeed north-eaſt and ſouth-weſt. Perhaps if it had lain acroſs the wind, the effect might have been different. But on this I can give no certainty. It ſeems a matter proper to be referred to experiment. Poſſibly a turncap might have been ſerviceable, but it was not tried.

Chimneys have not been long in uſe in England. I formerly ſaw a book, printed in the time of queen Elizabeth, which remarked the then modern improvements of living, and mentioned among others the convenience of chimneys. "Our forefathers," ſaid the author, "had no chimneys. There was in each dwelling-houſe only a place for a fire, and the

" ſmoke went out through a hole in the roof; " but now there is ſcarce a gentleman's houſe " in England that has not at leaſt one chimney in it."—When there was but one chimney, its top might then be opened as a funnel, and perhaps, borrowing the form from the Venetians, it was then the flue of a chimney got that name. Such is now the growth of luxury, that in both England and France we muſt have a chimney for every room, and in ſome houſes every poſſeſſor of a chamber, and almoſt every ſervant, will have a fire; ſo that the flues being neceſſarily built in ſtacks, the opening of each as a funnel is impracticable. This change of manners ſoon conſumed the firewood of England, and will ſoon render fuel extremely ſcarce and dear in France, if the uſe of coals be not introduced in the latter kingdom, as it has been in the former, where it at firſt met with oppoſition; for there is extant in the records of one of queen Elizabeth's parliaments, a motion made by a member, reciting, " that many dyers, brewers, ſmiths, " and other artificers of London, had of late " taken to the uſe of pitcoal for their fires, " inſtead of wood, which filled the air with " noxious vapours and ſmoke, very prejudicial " to the health, particularly of perſons coming out of the country; and therefore moving that a law might paſs to prohibit the " uſe of ſuch fuel (at leaſt during the ſeſſion " of parliament) by thoſe artificers."—It ſeems it was not then commonly uſed in private houſes. Its ſuppoſed unwholeſomeneſs was an objection. Luckily the inhabitants of London have got over that objection, and now think it rather contributes to render their air ſalubrious, as they have had no general peſtilential diſorder ſince the general uſe of coals, when, before it, ſuch were frequent. Paris ſtill burns wood at an enormous expence continually augmenting, the inhabitants having ſtill that prejudice to overcome. In Germany you are happy in the uſe of ſtoves, which ſave fuel wonderfully: your people are very ingenious in the management of fire; but they may ſtill learn ſomething in that art from the Chineſe*, whoſe country being greatly populous and fully cultivated, has little room left for the growth of wood, and having not much other fuel that is good, have been forced upon many inventions, during a courſe of ages, for making a little fire go as far as poſſible.

I have thus gone through all the common cauſes of the ſmoking of chimneys that I can at preſent recollect as having fallen under my obſervation; communicating the remedies that I have known ſucceſsfully uſed for the different caſes, together with the principles on which both the diſeaſe and the remedy depend, and confeſſing my ignorance wherever I have been ſenſible of it. You will do well, if you publiſh, as you propoſe, this letter, to add in notes, or as you pleaſe, ſuch obſervations as may have occurred to your attentive mind; and if other philoſophers will do the ſame, this part of ſcience, though humble, yet of great utility, may in time be perfected. For many years paſt, I have rarely met with a caſe of a ſmoky chimney, which has not been ſolvable on theſe principles, and cured by theſe remedies, where people have been willing to apply them: which is indeed not always the caſe; for many have prejudices in favour of the noſtrums of pretending chimney-doctors and fumiſts, and ſome have conceits and fancies of their own, which they rather chooſe to try, than to lengthen a funnel, alter the ſize of an opening, or admit air into a room, however neceſſary; for ſome are as much afraid of freſh air as perſons in the hydrophobia are of freſh water. I myſelf had formerly this prejudice, this *aerophobia*, as I now account it, and dreading the ſuppoſed dangerous effects of cool air, I conſidered it as an enemy, and cloſed with extreme care every crevice in the rooms I inhabited. Experience has convinced me of my error. I now look upon freſh air as a friend; I even ſleep with an open window. I am perſuaded that no common air from without, is ſo unwholeſome as the air within a cloſe room that has been often breathed and not changed. Moiſt air too, which formerly I thought pernicious, gives me now no apprehenſions: for conſidering that no dampneſs of air applied to the outſide of my ſkin, can be equal to what is applied to and touches it within, my whole body being full of moiſture, and finding that I can lie two hours in a bath twice a week, covered with water, which certainly is much damper than any air can be, and this for years together, without catching cold, or being in any other manner diſordered by it, I no longer dread mere moiſture, either in air or in ſheets or ſhirts: and I find it of importance to the happineſs of life, the being freed from vain terrors, eſpecially of objects that we are every day expoſed inevitably to meet with. You phyſicians have of late happily diſcovered, after a contrary opinion had prevailed ſome ages, that freſh and cool air does good to perſons in the ſmall-pox and other fevers. It is to be hoped that in another century or two we may all find out, that it is not bad even for people in health. And as to moiſt air, here I am at this preſent writing in a ſhip with above forty perſons, who have had no other but moiſt air to breathe for ſix weeks paſt; every thing we touch is damp, and nothing dries; yet we are all as healthy as we ſhould be on the mountains of Switzerland, whoſe inhabitants are not more ſo than thoſe of Bermuda or St. Helena, iſlands on whoſe rocks the waves are daſhed into millions of particles, which fill the air with damp, but produce no diſeaſes, the moiſture being pure, unmixed with the poiſonous vapours ariſing from putrid marſhes and ſtagnant pools, in which many inſects die, and corrupt the water. Theſe places only, in my opinion (which however I ſubmit to yours), afford unwholeſome air; and that it is not the mere water contained in damp air, but the volatile particles of corrupted animal matter mixed with that water, which renders ſuch air pernicious to thoſe who breathe it. And I imagine it a cauſe of the ſame kind that renders the air in cloſe rooms, where the perſpirable matter is breathed over and over again by a number of aſſembled people, ſo hurtful to health. After being in ſuch a ſituation, many find themſelves affected by that *febricula*, which the Engliſh alone call *a cold*, and, perhaps from the name, imagine that they caught the malady by *going out* of the room, when it was in fact by being in it.

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* See Appendix, No. III.

You begin to think that I wander from my ſubject, and go out of my depth. So I return again to my chimneys.

We have of late many lecturers in experimental philoſophy. I have wiſhed that ſome of them would ſtudy this branch of that ſcience, and give experiments in it as a part of their lectures. The addition to their preſent apparatus need not be very expenſive. A number of little repreſentations of rooms, compoſed each of five panes of ſaſh glaſs, framed in wood at the corners, with proportionable doors, and moveable glaſs chimneys, with openings of different ſizes, and different lengths of funnel, and ſome of the rooms ſo contrived as to communicate on occaſion with others, ſo as to form different combinations, and exemplify different caſes; with quantities of green wax taper cut into pieces of an inch and half, ſixteen of which ſtuck together in a ſquare, and lit, would make a ſtrong fire for a little glaſs chimney, and blown out would continue to burn and give ſmoke as long as deſired: with ſuch an apparatus all the operations of ſmoke and rarefied air in rooms and chimneys might be ſeen through their tranſparent ſides; and the effect of winds on chimneys, commanded or otherwiſe, might be ſhewn by letting the entering air blow upon them through an opened window of the lecturer's chamber, where it would be conſtant while he kept a good fire in his chimney. By the help of ſuch lectures our fumiſts would become better inſtructed. At preſent they have generally but one remedy, which perhaps they have known effectual in ſome one caſe of ſmoky chimneys, and they apply that indiſcriminately to all the other caſes, without ſucceſs,—but not without expence to their employers.

With all the ſcience, however, that a man ſhall ſuppoſe himſelf poſſeſſed of in this article, he may ſometimes meet with caſes that ſhall puzzle him. I once lodged in a houſe at London, which, in a little room, had a ſingle chimney and funnel. The opening was very ſmall, yet it did not keep in the ſmoke, and all attempts to have a fire in this room were fruitleſs. I could not imagine the reaſon, till at length obſerving that the chamber over it, which had no fire-place in it, was always filled with ſmoke when a fire was kindled below, and that the ſmoke came through the cracks and crevices of the wainſcot; I had the wainſcot taken down, and diſcovered that the funnel which went up behind it, had a crack many feet in length, and wide enough to admit my arm, a breach very dangerous with regard to fire, and occaſioned probably by an apparent irregular ſettling of one ſide of the houſe. The air entering this breach freely, deſtroyed the drawing force of the funnel. The remedy would have been, filling up the breach, or rather rebuilding the funnel: but the landlord rather choſe to ſtop up the chimney.

Another puzzling caſe I met with at a friend's country houſe near London. His beſt room had a chimney in which, he told me, he never could have a fire, for all the ſmoke came out into the room. I flattered myſelf I could eaſily find the cauſe, and preſcribe the cure. I had a fire made there, and found it as he ſaid. I opened the door, and perceived it was not want of air. I made a temporary contraction of the opening of the chimney, and found that it was not its being too large that cauſed the ſmoke to iſſue. I went out and looked up at the top of the chimney: its funnel was joined in the ſame ſtack with others, ſome of them ſhorter, that drew very well, and I ſaw nothing to prevent its doing the ſame. In fine, after every other examination I could think of, I was obliged to own the inſufficiency of my ſkill. But my friend, who made no pretenſion to ſuch kind of knowledge, afterwards diſcovered the cauſe himſelf. He got to the top of the funnel by a ladder, and, looking down, found it filled with twigs and ſtraw, cemented by earth, and lined with feathers. It ſeems the houſe, after being built, had ſtood empty ſome years before he occupied it; and he concluded that ſome large birds had taken the advantage of its retired ſituation to make their neſt there. The rubbiſh, conſiderable in quantity, being removed, and the funnel cleared, the chimney drew well, and gave ſatisfaction.

In general, ſmoke is a very tractable thing, eaſily governed and directed, when one knows the principles, and is well informed of the circumſtances. You know I made it *deſcend* in my Pennſylvania ſtove. I formerly had a more ſimple conſtruction, in which the ſame effect was produced, but viſible to the eye. It was compoſed of two plates *A B* and *C D*, placed as in the figure*. The lower plate *AB* reſted with its edge in the angle made by the hearth with the back of the chimney. The upper plate was fixt to the breaſt, and lapt over the lower about ſix inches, leaving a ſpace of four inches wide, and the length of the plates (near two feet) between them. Every other paſſage of air into the funnel was well ſtopped. When therefore a fire was made at *E*, for the firſt time with charcoal, till the air in the funnel was a little heated through the plates, and then wood laid on, the ſmoke would riſe to *A*, turn over the edge of that plate, deſcend to *D*, then turn under the edge of the upper plate, and go up the chimney. It was pretty to ſee, but of no great uſe. Placing therefore the under plate in a higher ſituation, I removed the upper plate *C D*, and placed it perpendicularly, ſo that the upper edge of the lower plate *A B* came within about three inches of it*, and might be puſhed farther from it, or ſuffered to come nearer to it, by a moveable wedge between them. The flame then aſcending from the fire at *E*, was carried to ſtrike the upper plate, made it very hot, and its heat roſe and ſpread with the rarefied air into the room.

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* Plate I. Figure 7.

I believe you have ſeen in uſe with me, the contrivance of a ſliding plate over the fire, ſeemingly placed to oppoſe the riſing of the ſmoke, leaving but a ſmall paſſage for it, between the edge of the plate and the back of the chimney. It is particularly deſcribed, and its uſes explained, in my former printed letter, and I mention it here only as another inſtance of the tractability of ſmoke †.

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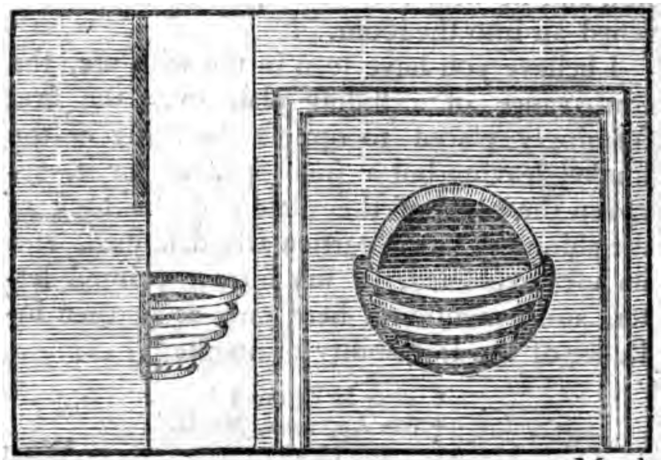
* Plate I. Figure 8.

† See Appendix, No. II.

What is called the Staffordſhire chimney, affords an example of the ſame kind. The opening of the chimney is bricked up, even with the fore edge of its jams, leaving open only a paſſage over the grate of the ſame width, and perhaps eight inches high. The grate conſiſts of ſemicircular bars, their upper bar of the greateſt diameter, the others under it ſmaller and ſmaller, ſo that it has the appearance of half a round baſket. It is, with the coals it contains, wholly without the wall that ſhuts up the chimney, yet the ſmoke bends and enters the paſſage above it, the draught being ſtrong, becauſe no air can enter that is not obliged to paſs near or through the fire, ſo that all that the funnel is filled with is much heated, and of courſe much rareſied.

STAFFORDSHIRE FIRE-PLACE.

SIDE VIEW. FRONT VIEW.



Much more of the proſperity of a winter country depends on the plenty and cheapneſs of fuel, than is generally imagined. In travelling I have obſerved, that in thoſe parts where the inhabitants can have neither wood, nor coal, nor turf, but at exceſſive prices, the working people live in miſerable hovels, are ragged, and have nothing comfortable about them. But where fuel is cheap (or where they have the art of managing it to advantage) they are well furniſhed with neceſſaries, and have decent habitations. The obious reaſon is, that the working hours of ſuch people are the profitable hours, and they who cannot afford ſufficient fuel, have fewer ſuch hours in the twenty-four than thoſe who have it cheap and plenty: for much of the domeſtic work of poor women, ſuch as ſpinning, ſewing, knitting; and of the men, in thoſe manufactures that require little bodily exerciſe, cannot well be performed where the fingers are numbed with cold: thoſe people, therefore, in cold weather, are induced to go to bed ſooner, and lie longer in a morning, than they would do if they could have good fires or warm ſtoves to ſit by; and their hours of work are not ſufficient to produce the means of comfortable ſubſiſtence. Thoſe public works, therefore, ſuch as roads, canals, &c. by which fuel may be brought cheap into ſuch countries from diſtant places, are of great utility; and thoſe who promote them may be reckoned among the benefactors of mankind.

I have great pleaſure in having thus complied with your requeſt, and in the reflection that the friendſhip you honour me with, and in which I have ever been ſo happy, has continued ſo many years without the ſmalleſt interruption. Our diſtance from each other is now augmented, and nature muſt ſoon put an end to the poſſibility of my continuing our correſpondence: but if conſciouſneſs and memory remain in a future ſtate, my eſteem and reſpect for you, my dear friend, will be everlaſting.

B. F.

APPENDIX.

NOTES FOR THE LETTER UPON CHIMNEYS.

No. I.

THE lateſt work on architecture that I have ſeen, is that entitled NUTSHELLS, which appears to be written by a very ingenious man, and contains a table of the proportions of the openings of chimneys; but they relate ſolely to the proportions he gives his rooms, without the ſmalleſt regard to the funnels. And he remarks, reſpecting thoſe proportions, that they are ſimilar to the harmonic diviſions of a monochord *. He does not indeed lay much ſtreſs on this; but it ſhows that we like the appearance of principles; and where we have not true ones, we have ſome ſatisfaction in producing ſuch as are imaginary.

No. II.

THE deſcription of the ſliding plates here promiſed, and which hath been ſince brought into uſe under various names, with

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* “ It may be juſt remarked here, that upon comparing
“ theſe proportions with thoſe ariſing from the common
“ diviſions of the monochord, it happens that the firſt an-
“ ſwers to uniſon; and although the ſecond is a diſcord, the
“ third anſwers to the third minor, the fourth to the third
“ major, the fifth to the fourth, the ſixth to the fifth, and
“ the ſeventh to the octave.” NUTSHELLS, page 85.

ſome immaterial changes, is contained in a former letter to J. B. Eſq. as follows:

To J. B. *Eſq. at Boſton, in New England.*

Dear Sir, London, Dec. 2, 1758.

I HAVE executed here an eaſy ſimple contrivance, that I have long ſince had in ſpeculation, for keeping rooms warmer in cold weather than they generally are, and with leſs fire. It is this. The opening of the chimney is contracted, by brick-work faced with marble ſlabs, to about two feet between the jams, and the breaſt brought down to within about three feet of the hearth.—An iron frame is placed juſt under the breaſt, and extending quite to the back of the chimney, ſo that a plate of the ſame metal may ſlide horizontally backwards and forwards in the grooves on each ſide of the frame. This plate is juſt ſo large as to fill the whole ſpace, and ſhut the chimney entirely when thruſt quite in, which is convenient when there is no fire. Drawing it out, ſo as to leave a ſpace between its further edge and the back, of about two inches; this ſpace is ſufficient for the ſmoke to paſs; and ſo large a part of the funnel being ſtopt by the reſt of the plate, the paſſage of warm air out of the room, up the chimney, is obſtructed and retarded, and by that means much cold air is prevented from coming in through crevices, to ſupply its place. This effect is made manifeſt three ways. Firſt, when the fire burns briſkly in cold weather, the howling or whiſtling noiſe made by the wind, as it enters the room through the crevices, when the chimney is open as uſual, ceaſes as ſoon as the plate is ſlid in to its proper diſtance. Secondly, opening the door of the room about half an inch, and holding your hand againſt the opening, near the top of the door, you feel the cold air coming in againſt your hand, but weakly, if the plate be in. Let another perſon ſuddenly draw it out, ſo as to let the air of the room go up the chimney, with its uſual freedom where chimneys are open, and you immediately feel the cold air ruſhing in ſtrongly. Thirdly, if ſomething be ſet againſt the door, juſt ſufficient, when the plate is in, to keep the door nearly ſhut, by reſiſting the preſſure of the air that would force it open: then, when the plate is drawn out, the door will be forced open by the increaſed preſſure of the outward cold air endeavouring to get in to ſupply the place of the warm air, that now paſſes out of the room to go up the chimney. In our common open chimneys, half the fuel is waſted, and its effect loſt; the air it has warmed being immediately drawn off. Several of my acquaintance having ſeen this ſimple machine in my room, have imitated it at their own houſes, and it ſeems likely to become pretty common. I deſcribe it thus particularly to you, becauſe I think it would be uſeful in *Boſton*, where firing is often dear.

Mentioning chimneys puts me in mind of a property I formerly had occaſion to obſerve in them, which I have not found taken notice of by others; it is, that in the ſummer time, when no fire is made in the chimneys, there is, nevertheleſs, a regular draught of air through them; continually paſſing upwards, from about five or ſix o'clock in the afternoon, till eight or nine o'clock the next morning, when the current begins to ſlacken and heſitate a little, for about half an hour, and then ſets as ſtrongly down again, which it continues to do till towards five in the afternoon, then ſlackens and heſitates as before, going ſometimes a little up, then a little down, till in about half an hour it gets a ſteady upward current for the night, which continues till eight or nine the next day; the hours varying a little as the days lengthen and ſhorten, and ſometimes varying from ſudden changes in the weather; as if, after being long warm, it ſhould begin to grow cool about noon, while the air was coming down the chimney, the current will then change earlier than the uſual hour, *&c.*

This property in chimneys I imagine we might turn to ſome account, and render improper, for the future, the old ſaying, *as uſeleſs as a chimney in ſummer.* If the opening of the chimney, from the breaſt down to the hearth, be cloſed by a ſlight moveable frame or two, in the manner of doors, covered with canvas, that will let the air through, but keep out the flies; and another little frame ſet within upon the hearth, with hooks on which to hang joints of meat, fowls, *&c.* wrapt well in wet linen cloths, three or four fold; I am confident that if the linen is kept wet, by ſprinkling it once a day, the meat would be ſo cooled by the evaporation, carried on continually by means of the paſſing air, that it would keep a we e kor more in the hotteſt weather. Butter and milk might likewiſe be kept cool, in veſſels or bottles covered with wet cloths. A ſhallow tray, or keeler, ſhould be under the frame to receive any water that might drip from the wetted cloths. I think, too, that this property of chimneys might, by means of ſmoke-jack vanes, be applied to ſome mechanical purpoſes, where a ſmall but pretty conſtant power only is wanted.

If you would have my opinion of the cauſe of this changing current of air in chimneys, it is, in ſhort, as follows. In ſummer time there is generally a great difference in the warmth of the air at mid-day and mid-night, and, of courſe, a difference of ſpecific gravity in the air, as the more it is warmed the more it is rarefied. The funnel of a chimney being for the moſt part ſurrounded by the houſe, is protected, in a great meaſure, from the direct action of the ſun's rays, and alſo from the coldneſs of the night air. It thence preſerves a middle temperature between the heat of the day, and the coldneſs of the night. This middle temperature it communicates to the air contained in it. If the ſtate of the outward air be cooler than that in the funnel of the chimney, it will, by being heavier, force it to riſe, and go out at the top. What ſupplies its place from below, being warmed, in its turn, by the warmer funnel, is likewiſe forced up by the colder and weightier air below, and ſo the current is continued till the next day, when the ſun gradually changes the ſtate of the outward air, makes it firſt warm as the funnel of the chimney can make it (when the current begins to heſitate), and afterwards warmer. Then the funnel being cooler than the air that comes into it, cools that air, makes it heavier than the outward air, of courſe it deſcends; and what ſucceeds it from above being cooled in its turn, the deſcending current continues till towards evening, when it again heſitates and changes its courſe, from the change of warmth in the outward air, and the nearly remaining ſame middle temperature in the funnel.

Upon this principle, if a houſe were built behind *Beacon-hill*, an adit carried from one of the doors into the hill horizontally, till it met with a perpendicular ſhaft ſunk from its top, it ſeems probable to me, that thoſe who lived in the houſe, would conſtantly, in the heat even of the calmeſt day, have as much cool air paſſing through the houſe, as they ſhould chooſe; and the ſame, though reverſed in its current, during the ſtilleſt night.

I think, too, this property might be made of uſe to miners; as where ſeveral ſhafts or pits are ſunk perpendicularly into the earth, communicating at bottom by horizontal paſſages, which is a common caſe, if a chimney of thirty or forty feet high were built over one of the ſhafts, or ſo near the ſhaft, that the chimney might communicate with the top of the ſhaft; all air being excluded but what ſhould paſs up or down by the ſhaft, a conſtant change of air would, by this means, be produced in the paſſages below, tending to ſecure the workmen from thoſe damps which ſo frequently incommode them: for the freſh air would be almoſt always going down the open ſhaft to go up the chimney, or down the chimney to go up the ſhaft. Let me add one obſervation more, which is, that if that part of the funnel of a chimney, which appears above the roof of a houſe, be pretty long, and have three of its ſides expoſed to the heat of the ſun ſucceſſively, viz. when he is in the eaſt, in the ſouth, and in the weſt, while the north ſide is ſheltered by the building from the cold northerly winds; ſuch a chimney will often be ſo heated by the ſun, as to continue the draught ſtrongly upwards, through the whole twenty-four hours, and often for many days together. If the outſide of ſuch a chimney be painted black, the effect will be ſtill greater, and the current ſtronger.

No. III.

No. III.

IT is ſaid the northern Chineſe have a method of warming their ground-floors, which is ingenious. Theſe floors are made of tile a foot ſquare and two inches thick, their corners being ſupported by bricks ſet on end, that are a foot long and four inches ſquare; the tiles, too, join into each other, by ridges and hollows along their ſides. This forms a hollow under the whole floor, which on one ſide of the houſe has an opening into the air, where a fire is made, and it has a funnel riſing from the other ſide to carry off the ſmoke. The fuel is a ſulphureous pitcoal, the ſmell of which in the room is thus avoided, while the floor, and of courſe the room, is well warmed. But as the under ſide of the floor muſt grow foul with ſoot, and a thick coat of ſoot prevents much of the direct application of the hot air to the tiles, I conceive that burning the ſmoke, by obliging it to deſcend through red coals, would in this conſtruction be very advantageous, as more heat would be given by the flame than by the ſmoke, and the floor being thereby kept free from ſoot, would be more heated with leſs fire. For this purpoſe I would propoſe erecting the funnel cloſe to the grate, ſo as to have only an iron plate between the fire and the funnel, through which plate the air in the funnel being heated, it will be ſure to draw well, and force the ſmoke to deſcend, as in the figure*, where *A* is the funnel or chimney, *B* the grate on which the fire is placed, *C* one of the apertures through which the deſcending ſmoke is drawn into the channel *D* of figure 10, along which channel it is conveyed by a circuitous route, as deſignated by the arrows, until it arrives at the ſmall aperture *E*, figure 10, through which it enters the funnel *F*. *G* in both figures is the iron plate againſt which the fire is made, which being heated thereby, will rarefy the air in that part of the funnel, and cauſe the ſmoke to aſcend rapidly. The flame thus dividing from the grate to the right and left, and turning in paſſages diſpoſed, as in figure 10, ſo as that every part of the floor may be viſited by it before it enters the funnel *F*, by the two paſſages *E E*, very little of the heat will be loſt, and a winter room thus rendered very comfortable.

No. IV.

PAGE 12. *Few can imagine*, &c. It is ſaid the Icelanders have very little fuel, chiefly drift wood that comes upon their coaſt. To receive more advantage from its heat, they make their doors low, and have a ſtage round the room above the door, like a gallery, wherein the women can ſit and work, the men read or write, &c. The roof being tight, the warm air is confined by it, and kept from riſing higher and eſcaping; and the cold air, which enters the houſe when the door is opened, cannot riſe above the level of the top of the door, becauſe it is heavier than the warm air above the door, and ſo thoſe in the gallery are not incommoded by it. Some of our too lofty rooms might have a ſtage ſo conſtructed as to make a temporary gallery above, for the winter, to be taken away in ſummer. Sedentary people would find much comfort there in cold weather.

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* Plate I. Figure 9.

No. V.

PAGE 37. *Where they have the art of managing it*, &c. In ſome houſes of the lower people among the northern nations of Europe, and among the poorer ſort of Germans in Pennſylvania, I have obſerved this conſtruction, which appears very advantageous. *A* is the kitchen with its chimney; *B* an iron ſtove in the ſtove-room *. In a corner of the chimney is a hole through the back into the ſtove, to put in fuel, and another hole above it to let the ſmoke of the ſtove come back into the chimney. As ſoon as the cooking is over, the brands in the kitchen chimney are put through the hole to ſupply the ſtove, ſo that there is ſeldom more than one fire burning at a time. In the floor over the ſtove-room is a ſmall trap-door, to let the warm air riſe occaſionally into the chamber. Thus the whole houſe is warmed at little expence of wood, and the ſtove-room kept conſtantly warm; ſo that in the coldeſt winter nights, they can work late, and find the room ſtill comfortable when they riſe to work early. An Engliſh farmer in America, who makes great fires in large open chimneys, needs the conſtant employment of one man to cut and haul wood for ſupplying them; and the draught of cold air to them is ſo ſtrong, that the heels of his family are frozen while they are ſcorching their faces, and the room is never warm, ſo that little ſedentary work can be done by them in winter. The difference in this article alone of œconomy ſhall, in a courſe of years, enable the German to buy out the Engliſhman, and take poſſeſſion of his plantation.

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* Plate I. Figure 11.

MISCELLANEOUS OBSERVATIONS.

CHIMNEYS whoſe funnels go up in the north wall of a houſe, and are expoſed to the north winds, are not ſo apt to draw well as thoſe in a ſouth wall; becauſe, when rendered cold by thoſe winds, they draw downwards.

Chimneys encloſed in the body of a houſe are better than thoſe whoſe funnels are expoſed in cold walls.

Chimneys in ſtacks are apt to draw better than ſeparate funnels, becauſe the funnels that have conſtant fires in them, warm the others in ſome degree that have none.

One of the funnels in a houſe I once occupied,

pied, had a particular funnel joined to the ſouth ſide of the ſtack, ſo that three of its ſides were expoſed to the ſun in the courſe of the day, viz. the eaſt ſide *E** during the morning, the ſouth ſide *S* in the middle part of the day, and the weſt ſide *W* during the afternoon, while its north ſide was ſheltered by the ſtack from the cold winds. This funnel, which came from the ground floor, and had a conſiderable height above the roof, was conſtantly in a ſtrong drawing ſtate, day and night, winter and ſummer.

Blacking of funnels expoſed to the ſun, would probably make them draw ſtill ſtronger.

In Paris I ſaw a fire-place ſo ingeniouſly contrived as to ſerve conveniently two rooms, a bedchamber, and a ſtudy. The funnel over the fire was round. The fire-place was of caſt iron, having an upright back *A*†, and two horizontal ſemicircular plates *B C*, the whole ſo ordered as to turn on the pivots *D E*. The plate *B* always ſtopped that part of the round funnel that was next to the room without fire, while the other half of the funnel over the fire was always open. By this means a ſervant in the morning could make a fire on the hearth *C*, then in the ſtudy, without diſturbing the maſter by going into his chamber; and the maſter when he roſe, could with a touch of his foot turn the chimney on its pivots, and bring the fire into his chamber, keep it there as long as he wanted it, and turn it again when he went out into his ſtudy. The room which had no fire in it was alſo warmed by the heat coming through the back plate, and ſpreading in the room, as it could not go up the chimney.

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* Plate I. Figure 12.

† Plate I. Figure 13.

To His Excellency BENJAMIN FRANKLIN, *Eſq.* *L. L. D. Preſident of the State of Pennſylvania, and of the American Philoſophical Society*, &c.

SIR, Philadelphia, January 12, 1786.

THE ſubject of ſmoky chimneys, of which I had the honour of converſing with you at your own houſe laſt evening, is of ſo much importance to every individual, as well as to every private family, that too much light cannot be thrown upon it.

A ſmoky houſe, and a ſcolding wife,
Are (ſaid to be) two of the greateſt ills in life.

And however difficult it may be to remedy one of thoſe ills, yet any advances we may be able to make towards removing the inconveniences ariſing from the other, cannot fail to be favourably received by the public. As they are ſhortly to be favoured with your ſentiments on that ſubject, poſſibly the following obſervations, which were in fact occaſioned by neceſſity, and are the reſult of my own experience, may not be altogether undeſerving of notice.

When I left London, and went to live in Devonſhire, in the latter end of the year 1777, it happened to be my lot to dwell in an old manſion which had been recently moderniſed, and had undergone a thorough repair. But as in moſt of the old houſes in England, the chimneys, which were perhaps originally built for the purpoſe of burning wood, though they had been contracted in front, ſince coal fires came into general uſe, to the modern ſize, yet they were ſtill, above, out of ſight, extravagantly large. This method of building chimneys may perhaps have anſwered well enough while it was the cuſtom to ſit with the doors and windows open; but when the cuſtoms and manners of the people began to be more poliſhed and refined, when building and architecture were improved, and they began to conceive the idea of making their chambers cloſe, warm, and comfortable, theſe chimneys were found to ſmoke abominably, for want of a ſufficient ſupply of air. This was exactly the caſe with the houſe in which I firſt lived, near Exeter, and I was under the neceſſity of trying every expedient I could think of to make it habitable.

The firſt thing I tried was that method of contracting the chimneys by means of earthen pots, much in uſe in England, which are made on purpoſe, and which are put upon the tops of them; but this method by no means anſwered. I then thought of contracting them below; but as the method of contracting them in front to the ſize of a ſmall coal-fire grate has an unſightly appearance, as it makes a diſagreeable blowing like a furnace, and as it is the occaſion of conſuming a great deal of unneceſſary fuel, the heat of which is immediately hurried up the chimney, I rejected this method, and determined to contract them above, a little out of ſight. For this purpoſe I threw an arch acroſs, and alſo drew them in at the ſides. This had ſome effect; but as this contraction was made rather ſuddenly, and the ſmoke, by ſtriking againſt the corners that were thereby occaſioned, was apt to recoil, by which means ſome part of it was thrown out into the room, I determined to make the contraction more gradually, and therefore run it up at the back, where the depth of the chimney would admit of it, and alſo ſhelving or ſloping in a conical kind of direction at the ſides, as high as a man, ſtanding upright, could conveniently reach, and by this means brought the cavity within the ſpace of about twelve by fourteen or ſixteen inches, which I found ſufficiently large to admit a boy to go up and down to ſweep the chimneys. This method I found to ſucceed perfectly well as to curing the chimneys of ſmoking, and it had this good effect, of making the rooms conſiderably warmer; and as this experiment ſucceeded ſo well, ſince the only uſe of a chimney is to convey away the ſmoke, I determined to carry it ſtill farther, in order to aſcertain, with preciſion, how much ſpace is abſolutely neceſſary for that purpoſe, becauſe all the reſt that is ſhut up muſt be ſo much gained in warmth. Accordingly I laid a piece of ſlate acroſs the remaining aperture, removable at pleaſure, ſo as to contract the ſpace above two thirds, leaving about three inches by twelve remaining open; but this ſpace, except when the fire burnt remarkably clear, was ſcarcely ſufficient to carry away the ſmoke. I therefore enlarged it to half the ſpace, that is, to about ſix by ſeven or eight inches, which I found fully ſufficient to carry away the ſmoke from the largeſt fires.

When I removed into the Bedford Circus in Exeter, though the houſe was modern, and almoſt perfectly new, yet the chimneys were large; in conſequence of which almoſt every room of it ſmoked. My predeceſſor, who was the firſt inhabitant, had been at great expence in patent ſtoves, &c. but without effect; but by adopting the method I have juſt now deſcribed, I not only cured every chimney of ſmoking, but my houſe was remarked for being one of the warmeſt and moſt comfortable to live in of any in that large and opulent city.

The houſe I now live in, in Philadelphia, I am told, has always had the character of being both cold and ſmoky; and I was convinced, as ſoon as I ſaw the rooms and examined the chimneys, that it deſerved that character; for though the rooms were cloſe, the chimneys were large: and we ſhall ever find, that if our chimneys are large, our rooms will be cold, even though they ſhould be tolerably cloſe and tight; becauſe the conſtant ruſhing in of the cold air at the cracks and crevices, and alſo at every opening of the door, will be ſufficient to chill the air as faſt as it is heated, or to force the heated air up the chimney; but by contracting the chimneys I have cured it of both theſe defects. There was one remarkable circumſtance attending the contraction of the chimney in the front parlour, which deſerves to be attended to; which was, that before I applied the caſt iron plate, which I made uſe of inſtead of ſlate, to diminiſh the ſpace requiſite for a chimney-ſweeper's boy to go up and down, the ſuction or draught of air was ſo great, that it was with difficulty I could ſhut the door of the room, inſomuch that I at firſt thought it was owing to a tightneſs of the hinges, which I imagined muſt be remedied; but upon applying the iron plate, by which the ſpace was diminiſhed one half, the door ſhut to with the greateſt eaſe. This extraordinary preſſure of the air upon the door of the room, or ſuction of the chimney, I take to be owing in ſome meaſure to the unuſual height of the houſe.

Upon the whole, therefore, this fact ſeems clearly aſcertained, viz. That the flue or ſize of the chimney ought always to be proportioned to the tightneſs and cloſeneſs of the room: ſome air is undoubtedly neceſſary to be admitted into the room in order to carry up the ſmoke, otherwiſe, as you juſtly obſerved, we might as well expect ſmoke to ariſe out of an exhauſted receiver; but if the flue is very large, either the room is tight, and the ſmoke will not aſcend, or it is pretty open, and the conſequence will be, that the air of your room will be ſo frequently and ſo conſtantly changed, that, as faſt as it is heated, it will be hurried away, with the ſmoke, up the chimney, and of courſe your room will be conſtantly cold.

One great advantage attending this method of curing ſmoky chimneys is, that, in the firſt place, it makes no awkward or unſightly appearance, nothing being to be ſeen but what is uſual to chimneys in common; and, in the ſecond place, that it is attended with very little expence, a few bricks and mortar, with a plate or covering to the aperture, and a little labour, being all that is requiſite. But in this new country, where crops of houſes may be expected to riſe almoſt as quick as fields of corn, when the principles upon which chimneys ſhould be erected ought to be thoroughly underſtood, it is to be hoped, that not only this expence, ſmall as it is, but that all the other inconveniences we have been ſpeaking of, will be avoided, by conſtructing the flues of the chimneys ſufficiently ſmall.

From your humble ſervant,

THOMAS RUSTON.

Deſcription

Deſcription of a new STOVE *for burning of Pitcoal, and conſuming all its Smoke.*

BY DR. B. FRANKLIN.

TOWARDS the end of the laſt century, an ingenious French philoſopher, whoſe name I am ſorry I cannot recollect, exhibited an experiment to ſhow that very offenſive things might be burnt in the middle of a chamber, ſuch as woollen rags, feathers, &c. without creating the leaſt ſmoke or ſmell. The machine in which the experiment was made, if I remember right, was of this form *, made of plate iron. Some clear-burning charcoals were put into the opening of the ſhort tube *A*, and ſupported there by the grate *B*. The air, as ſoon as the tubes grew warm, would aſcend in the longer leg *C*, and go out at *D*, conſequently air muſt enter at *A* deſcending to *B*. In this courſe it muſt be heated by the burning coals through which it paſſed, and riſe more forcibly in the longer tube, in proportion to its degree of heat or rarefaction, and length of that tube. For ſuch a machine is a kind of inverted ſyphon: and as the greater weight of water in the longer leg of a common ſyphon, in deſcending, is accompanied by an aſcent of the ſame fluid in the ſhorter; ſo, in this inverted ſyphon, the greater quantity of levity of air in the longer leg, in riſing, is accompanied by the deſcent of air in the ſhorter. The things to be burned being laid on the hot coals at *A*, the ſmoke muſt deſcend through thoſe coals, and be converted into flame, which, after deſtroying the offenſive ſmell, comes out at the end of the longer tube as mere heated air.

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* Plate II. Figure 1.

Whoever would repeat this experiment with ſucceſs, muſt take care that the part *A B*, of the ſhort tube, be quite full of burning coals, ſo that no part of the ſmoke may deſcend and paſs by them without going through them, and being converted into flame; and that the longer tube be ſo heated as that the current of aſcending hot air is eſtabliſhed in it before the things to be burnt are laid on the coals; otherwiſe there will be a diſappointment.

It does not appear, either in the Memoirs of the Academy of Sciences, or Philoſophical Tranſactions of the Engliſh Royal Society, that any improvement was ever made of this ingenious experiment, by applying it to uſeful purpoſes. But there is a German book, entitled *Vulcanus Famulans*, by John George Leutmann, P. D. printed at Wirtemberg in 1723, which deſcribes, among a great variety of other ſtoves for warming rooms, one which ſeems to have been formed on the ſame principle, and probably from the hint thereby given, though the French experiment is not mentioned. This book being ſcarce, I have tranſlated the chapter deſcribing the ſtove, viz.

“ Vulcanus Famulans, by John George Leutmann, P. D. Wirtemberg, 1723.

“ CHAP. VII.

“ On a ſtove which draws downwards.

“ Here follows the deſcription of a ſort of “ ſtove, which can eaſily be removed, and again “ replaced, at pleaſure. This drives the fire “ down under itſelf, and gives no ſmoke, but “ however a very unwholeſome vapour.

“ In the figure, *A* is an iron veſſel like a “ funnel*, in diameter at the top about twelve “ inches; at the bottom, near the grate, about “ five inches; its height twelve inches. This “ is ſet on the barrel *C*, which is ten inches “ diameter, and two feet long, cloſed at each “ end *E E*. From one end riſes a pipe or flue “ about four inches diameter, on which other “ pieces of pipe are ſet, which are gradually “ contracted to *D*, where the opening is but “ about two inches. Thoſe pipes muſt toge-“ ther be at leaſt four feet high. *B* is an iron “ grate. *F F* are iron handles guarded with “ wood, by which the ſtove is to be lifted and “ moved. It ſtands on three legs. Care muſt “ be taken to ſtop well all the joints, that no “ ſmoke may leak through.

“ When this ſtove is to be uſed, it muſt firſt “ be carried into the kitchen, and placed in

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* Plate II. Figure 20.

" the chimney near the fire. There burning " wood muſt be laid and left upon its grate " till the barrel *C* is warm, and the ſmoke no " longer riſes at *A*, but deſcends towards *C*. " Then it is to be carried into the room which " it is to warm. When once the barrel *C* " is warm, freſh wood may be thrown into the " veſſel *A* as often as one pleaſes; the flame " deſcends, and without ſmoke, which is ſo " conſumed that only a vapour paſſes out at *D*.

" As this vapour is unwholeſome, and affects the head, one may be freed from it, by " fixing in the wall of the room an inverted " funnel, ſuch as people uſe to hang over " lamps, through which their ſmoke goes out " as through a chimney. This funnel carries " out all the vapour cleverly, ſo that one finds " no inconvenience from it, even though the " opening *D* be placed a ſpan below the mouth " of the ſaid funnel *G*. The neck of the funnel is better when made gradually bending, " than if turned in a right angle.

" The cauſe of the draught downwards in " the ſtove is the preſſure of the outward air, " which falling into the veſſel *A* in a column " of twelve inches diameter, finds only a reſiſting paſſage at the grate *B* of five inches, " and one at *D* of two inches, which are much " too weak to drive it back again; beſides, *A* " ſtands much higher than *B*, and ſo the preſſure on it is greater and more forcible, and " beats down the flame to that part where it "finds the leaſt reſiſtance. Carrying the machine firſt to the kitchen fire for preparation is on this account, that, in the beginning, the fire and ſmoke naturally aſcend till the air in the cloſe barrel *C* is made thinner by the warmth. When that veſſel is heated, the air in it is rarefied, and then all the ſmoke and fire deſcends under it.

"The wood ſhould be thoroughly dry, and cut into pieces five or ſix inches long, to fit it for being thrown into the funnel *A*." Thus far the German book.

It appears to me, by Mr. Leutmann's explanation of the operation of this machine, that he did not underſtand the principles of it, whence I conclude he was not the inventor of it: and by the deſcription of it, wherein the opening at *A* is made ſo large, and the pipe *E D* ſo ſhort, I am perſuaded he never made nor ſaw the experiment; for the firſt ought to be much ſmaller, and the laſt much higher, or it hardly will ſucceed. The carrying it in the kitchen too, every time the fire ſhould happen to be out, muſt be ſo troubleſome that it is not likely ever to have been in practice, and probably has never been ſhown but as a philoſophical experiment. The funnel for conveying the vapour out of the room would beſides have been uncertain in its operation, as a wind blowing againſt its mouth would drive the vapour back.

The ſtove I am about to deſcribe, was alſo formed on the idea given by the French experiment,

riment, and completely carried into execution before I had any knowledge of the German invention; which I wonder ſhould remain ſo many years in a country where men are ſo ingenious in the management of fire, without receiving long ſince the improvements I have given it.

DESCRIPTION of the PARTS.

A, the bottom plate, which lies flat upon the hearth, with its partitions 1, 2, 3, 4, 5, 6, that are caſt with it, and a groove *Z Z*, in which are to ſlide the bottom edges of the ſmall plates *Y Y*, figure 12; which plates, meeting at *X*, cloſe the front *.

B 1, figure 3, is the cover plate ſhowing its under ſide, with the grooves 1, 2, 3, 4, 5, 6, to receive the top edges of the partitions that are fixed to the bottom plate. It ſhows alſo the grate *W W*, the bars of which are caſt in the plate, and a groove *V V*, which comes right over the groove *Z Z*, figure 2, receiving the upper edges of the ſmall ſliding plates *Y Y*, figure 12.

B 2, figure 4, ſhows the upper ſide of the ſame plate, with a ſquare impreſſion or groove for receiving the bottom mouldings *T T T T* of the three-ſided box *C*, figure 5, which is caſt in one piece.

D, figure 6, its cover, ſhowing its under ſide with grooves to receive the upper edges *S S S* of the ſides of *C*, figure 5; alſo a groove

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* Plate II. Figure 2.

R R, which, when the cover is put on, comes right over another *Q Q* in *C*, figure 5, between which it is to ſlide.

E, figure 7, the front plate of the box.

P, a hole three inches diameter through the cover *D*, figure 6; over which hole ſtands the vaſe *F*, figure 8, which has a correſponding hole two inches diameter through its bottom.

The top of the vaſe opens at *O O O*, figure 8, and turns back upon a hinge behind when coals are to be put in; the vaſe has a grate within at *N N* of caſt iron *H*, figure 9, and a hole in the top one inch and an half diameter to admit air, and to receive the ornamental braſs gilt flame *M*, figure 10, which ſtands in that hole, and, being itſelf hollow and open, ſuffers air to paſs through it to the fire.

G, figure 11, is a drawer of plate iron that ſlips in between in the partitions 2 and 3, figure 2, to receive the falling aſhes. It is concealed when the ſmall ſliding plates *Y Y*, figure 12, are ſhut together.

I I I I, figure 8, is a niche built of brick in the chimney, and plaſtered. It cloſes the chimney over the vaſe, but leaves two funnels, one in each corner, communicating with the bottom box *K K*, figure 2.

DIMENSIONS of the PARTS.

	Feet.	In.
Front of the bottom box - -	2	0
Height of its partitions - -	0	4¼

Length

	Feet.	In.
Length of No. 1, 2, 3, and 4, each	1	3
Length of No. 5 and 6, each	0	8¼
Breadth of the paſſage between No. 2 and 3	0	6
Breadth of the other paſſages, each	0	3½
Breadth of the grate	0	6½
Length of ditto	0	8
Bottom moulding of box *C*, ſquare	1	0
Height of the ſides of ditto	0	4
Length of the back ſide	0	10
Length of the right and left ſides, each	0	9½
Length of the front plate *E*, where longeſt	0	11
The cover *D*, ſquare	0	12
Hole in ditto, diameter	0	3
Sliding plates *Y Y*, their length each	1	0
———— their breadth each	0	4½
Drawer *G*, its length	1	0
———— breadth	0	5¼
———— depth	0	4
———— depth of its further end, only	0	1
Grate *H* in the vaſe, its diameter to the extremity of its knobs	0	5¾
Thickneſs of the bars at top	0	0¼
———— at bottom, leſs	0	0
Depth of the bars at the top	0	0¾

Height

	Feet.	In.
Height of the vaſe - - -	1	6
Diameter of the opening *O O*, in the clear - - - - -	0	8
——— of the air-hole at top -	0	1½
——— of the flame-hole at bottom - - - - -	0	2

To fix this Machine.

Spread mortar on the hearth to bed the bottom plate *A*; then lay that plate level, equally diſtant from each jamb, and projecting out as far as you think proper. Then putting ſome Windſor loam in the grooves of the cover *B*, lay that on; trying the ſliding plates *Y Y*, to ſee if they move freely in the grooves *Z Z*, *V V*, deſigned for them.

Then begin to build the niche, obſerving to leave the ſquare corners of the chimney unfilled; for they are to be funnels. And obſerve alſo to leave a free open communication between the paſſages at *K K*, and the bottom of thoſe funnels; and mind to cloſe the chimney above the top of the niche, that no air may paſs up that way. The concave back of the niche will reſt on the circular iron partition 1 *A* 4, figure 2; then, with a little loam put on the box *C* over the grate, the open ſide of the box in front.

Then, with loam in three of its grooves, the groove *R R* being left clean, and brought directly over the groove *Q Q* in the box, put on the cover *D*, trying the front plate *E*, to ſee if it ſlides freely in thoſe grooves.

Laſtly, ſet on the vaſe, which has ſmall holes in the moulding of its bottom to receive two iron pins that riſe out of the plate *D* at *I I*, for the better keeping it ſteady.

Then putting in the grate *H*, which reſts on its three knobs *H H H* againſt the inſide of the vaſe; and ſlipping the drawer into its place, the machine is fit for uſe.

To uſe it.

Let the firſt fire be made after eight in the evening, or before eight in the morning; for at thoſe times and between thoſe hours all night, there is uſually a draft up a chimney, though it has long been without fire; but between thoſe hours in the day there is often in a cold chimney a draft downwards, when, if you attempt to kindle a fire, the ſmoke will come into the room.

But to be certain of your proper time, hold a flame over the air-hole at the top. If the flame is drawn ſtrongly down for a continuance, without whiffling, you may begin to kindle a fire.

Firſt put in a few charcoals on the grate *H*,
Lay ſome ſmall ſticks on the charcoals,
Lay ſome pieces of paper on the ſticks,
Kindle the paper with a candle,

Then ſhut down the top, and the air will paſs down through the air-hole: blow the flame of the paper down through the ſticks, kindle them, and their flame paſſing lower, kindles the charcoal.

When the charcoal is well kindled, lay on it the ſea-coals, obſerving not to choak the fire by putting on too much at firſt.

The flame deſcending through the hole in the bottom of the vaſe, and that in plate *D* into the box *C*, paſſes down farther through the grate *W W* in plate *B* 1, then paſſes horizontally towards the back of the chimney; there dividing, and turning to the right and left, one part of it paſſes round the far end of the partition 2; then coming forward, it turns round the near end of partition 1; then moving backward, it arrives at the opening into the bottom of one of the upright corner funnels behind the niche, through which it aſcends into the chimney, thus heating that half of the box and that ſide of the niche. The other part of the divided flame paſſes round the far end of partition 3, round the near end of partition 4, and ſo into and up the other corner funnel, thus heating the other half of the box, and the other ſide of the niche. The vaſe itſelf, and the box *C*, will alſo be very hot; and the air ſurrounding them being heated, and riſing, as it cannot get into the chimney, it ſpreads in the room; colder air ſucceeding is warmed in its turn, riſes and ſpreads, till by the continual circulation the whole is warmed.

If you ſhould have occaſion to make your firſt fire at hours not ſo convenient as thoſe above mentioned, and when the chimney does not draw, do not begin it in the vaſe, but in one or more of the paſſages of the lower plate, firſt covering the mouth of the vaſe. After the chimney has drawn a while with the fire thus low, and begins to be a little warm, you may cloſe thoſe paſſages, and kindle another fire in the box *C*, leaving its ſliding ſhutter a little open; and when you find after ſome time that the chimney being warmed draws forcibly, you may ſhut that paſſage, open your vaſe, and kindle your fire there, as above directed. The chimney well warmed by the firſt day's fire will continue to draw conſtantly all winter, if fires are made daily.

You will, in the management of your fire, have need of the following implements:

A pair of ſmall light tongs, twelve or fifteen inches long, plate II. figure 13.

A light poker about the ſame length, with a flat broad point, figure 14.

A rake to draw aſhes out of the paſſages of the lower plate, where the lighter kind eſcaping the aſh-box, will gather by degrees, and, perhaps once in a week or ten days, require being removed, figure 15.

And a fork, with its prongs wide enough to ſlip on the neck of the vaſe cover, in order to raiſe and open it when hot, to put in freſh coals, figure 16.

In the management of this ſtove there are certain precautions to be obſerved at firſt with attention, till they become habitual. To avoid the inconvenience of ſmoke, ſee that the grate *H* be clear before you begin to light a freſh fire. If you find it clogged with cinders and aſhes, turn it up with your tongs, and let them fall upon the grate below; the aſhes will go through it, and the cinders may be raked off, and returned into the vaſe, when you would burn them. Then ſee that all the ſliding plates are in their places, and cloſe ſhut, that no air may enter the ſtove but through the round opening at the top of the vaſe. And, to avoid the inconvenience of duſt from the aſhes, let the aſh-drawer be taken out of the room to be emptied; and when you rake the paſſages, do it when the draft of the air is ſtrong inwards, and put the aſhes carefully into the aſh-box, that remaining in its place.

If, being about to go abroad, you would prevent your fire burning in your abſence, you may do it by taking the braſs flame from the top of the vaſe, and covering the paſſage with a round tin plate, which will prevent the entry of more air than barely ſufficient to keep a few of the coals alive. When you return, though ſome hours abſent, by taking off the tin plate, and admitting the air, your fire will ſoon be recovered.

The effect of this machine, well managed, is to burn not only the coals, but all the ſmoke of the coals; ſo that while the fire is burning, if you go out and obſerve the top of your chimney, you will ſee no ſmoke iſſuing, nor any thing but clear warm air, which, as uſual, makes the bodies ſeen through it appear waving.

But let none imagine from this, that it may be a cure for bad or ſmoky chimneys, much leſs that, as it burns the ſmoke, it may be uſed in a room that has no chimney. It is by the help of a good chimney, the higher the better, that it produces its effect; and though a flue of plate iron ſufficiently high might be raiſed in a very lofty room, the management to prevent all diſagreeable vapour would be too nice for common practice, and ſmall errors would have unpleaſing conſequences.

It is certain that clean iron yields no offenſive ſmell when heated. Whatever of that kind you perceive, where there are iron ſtoves, proceeds therefore from ſome foulneſs burning or fuming on their ſurface. They ſhould therefore never be ſpit upon, or greaſed, nor ſhould any duſt be ſuffered to lie upon them. But as the greateſt care will not always prevent theſe things, it is well once a week to waſh the ſtove with ſoap lees and a bruſh, rinſing it with clean water.

The Advantages of this Stove.

1. The chimney does not grow foul, nor ever need ſweeping; for as no ſmoke enters it, no ſoot can form in it.

2. The air heated over common fires inſtantly quits the room, and goes up the chim-

ney with the ſmoke; but in the ſtove, it is obliged to deſcend in flame, and paſs through the long winding horizontal paſſages, communicating its heat to a body of iron plate, which having thus time to receive the heat, communicates the ſame to the air of the room, and thereby warms it to a greater degree.

3. The whole of the fuel is conſumed by being turned into flame, and you have the benefit of its heat; whereas in common chimneys a great part goes away in ſmoke, which you ſee as it riſes, but it affords you no rays of warmth. One may obtain ſome notion of the quantity of fuel thus waſted in ſmoke, by reflecting on the quantity of ſoot that a few weeks firing will lodge againſt the ſides of the chimney, and yet this is formed only of thoſe particles of the column of ſmoke that happen to touch the ſides in its aſcent. How much more muſt have paſſed off in the air? And we know that this ſoot is ſtill fuel; for it will burn and flame as ſuch, and when hard caked together, is indeed very like, and almoſt as ſolid as the coal it proceeds from. The deſtruction of your fuel goes on nearly in the ſame quantity whether in ſmoke or in flame: but there is no compariſon in the difference of heat given. Obſerve when freſh coals are firſt put on your fire, what a body of ſmoke ariſes. This ſmoke is for a long time too cold to take flame. If you then plunge a burning candle into it, the candle, inſtead of inflaming the ſmoke, will inſtantly be itſelf extinguiſhed. Smoke muſt have a certain degree of heat to be

inflammable.

inflammable. As ſoon as it has acquired that degree, the approach of a candle will inflame the whole body, and you will be very ſenſible of the difference of the heat it gives. A ſtill eaſier experiment may be made with the candle itſelf. Hold your hand near the ſide of its flame, and obſerve the heat it gives; then blow it out, the hand remaining in the ſame place, and obſerve what heat may be given by the ſmoke that riſes from the ſtill burning ſnuff. You will find it very little. And yet that ſmoke has in it the ſubſtance of ſo much flame, and will inſtantly produce it, if you hold another candle above it ſo as to kindle it. Now the ſmoke from the freſh coals laid on this ſtove, inſtead of aſcending and leaving the fire while too cold to burn, being obliged to deſcend through the burning coals, receives among them that degree of heat which converts it into flame, and the heat of that flame is communicated to the air of the room, as above explained.

4. The flame from the freſh coals laid on in this ſtove, deſcending through the coals already ignited, preſerves them long from conſuming, and continues them in the ſtate of red coals as long as the flame continues that ſurrounds them; by which means the fires made in this ſtove are of much longer duration than in any other, and fewer coals are therefore neceſſary for a day. This is a very material advantage indeed. That flame ſhould be a kind of pickle to preſerve burning coals from conſuming,

ſuming, may ſeem a paradox to many, and very unlikely to be true, as it appeared to me the firſt time I obſerved the fact. I muſt therefore relate the circumſtances, and ſhall mention an eaſy experiment, by which my reader may be in poſſeſſion of every thing neceſſary to the underſtanding of it. In the firſt trial I made of this kind of ſtove, which was conſtructed of thin plate iron, I had inſtead of the vaſe a kind of inverted pyramid, like a mill-hopper; and fearing at firſt that the ſmall grate contained in it might be clogged by cinders, and the paſſage of the flame ſometimes obſtructed, I ordered a little door near the grate, by means of which I might on occaſion clear it; though after the ſtove was made, and before I tried it, I began to think this precaution ſuperfluous, from an imagination, that the flame being contracted in the narrow part where the grate was placed, would be more powerful in conſuming what it ſhould there meet with, and that any cinders between or near the bars would be preſently deſtroyed, and the paſſage opened. After the ſtove was fixed and in action, I had a pleaſure now and then in opening that door a little, to ſee through the crevice how the flame deſcended among the red coals; and obſerving once a ſingle coal lodged on the bars in the middle of the focus, a fancy took me to obſerve by my watch in how ſhort a time it would be conſumed. I looked at it long without perceiving it to be at all diminiſhed, which ſurpriſed me greatly. At length it occurred to me, that I and many others had ſeen the ſame thing thouſands of times, in the conſervation of the red coal formed in the ſnuff of a burning candle, which, while enveloped in flame, and thereby prevented from the contact of paſſing air, is long continued, and augments inſtead of diminiſhing, ſo that we are often obliged to remove it by the ſnuffers, or bend it out of the flame into the air, where it conſumes preſently to aſhes. I then ſuppoſed, that to conſume a body by fire, paſſing air was neceſſary to receive and carry off the ſeparated particles of the body; and that the air paſſing in the flame of my ſtove, and in the flame of a candle, being already ſaturated with ſuch particles, could not receive more, and therefore left the coal undiminiſhed as long as the outward air was prevented from coming to it by the ſurrounding flame, which kept it in a ſituation ſomewhat like that of charcoal in a well luted crucible, which, though long kept in a ſtrong fire, comes out unconſumed.

An eaſy experiment will ſatisfy any one of this conſerving power of flame enveloping red coal. Take a ſmall ſtick of deal, or other wood, the ſize of a gooſe quill, and hold it horizontally and ſteadily in the flame of the candle above the wick, without touching it, but in the body of the flame. The wood will firſt be inflamed, and burn beyond the edge of the flame of the candle, perhaps a quarter of an inch. When the flame of the wood goes out, it will leave a red coal at the end of the ſtick, part of which will be in the flame of the candle and part out in the air. In a minute or two you will perceive the coal in the air diminiſh gradually, ſo as to form a neck; while the part in the flame continues of its firſt ſize, and at length the neck being quite conſumed, it drops off; and by rolling it between your fingers when extinguiſhed, you will find it ſtill a ſolid coal.

However, as one cannot be always putting on freſh fuel in this ſtove to furniſh a continual flame, as is done in a candle, the air in the intervals of time gets at the red coals, and conſumes them. Yet the conſervation, while it laſted, ſo much delayed the conſumption of the coals, that two fires, one made in the morning, and the other in the afternoon, each made by only a hatful of coals, were ſufficient to keep my writing-room, about ſixteen feet ſquare and ten high, warm a whole day. The fire kindled at ſeven in the morning would burn till noon; and all the iron of the machine, with the walls of the niche, being thereby heated, the room kept warm till evening, when another ſmaller fire kindled kept it warm till midnight.

Inſtead of the ſliding plate *E*, which ſhuts the front of the box *C*, I ſometimes uſed another, which had a pane of glaſs, or, which is better, of Muſcovy talc, that the flame might be ſeen deſcending from the bottom of the vaſe, and paſſing in a column through the box *C*, into the cavities of the bottom plate, like water falling from a funnel, admirable to ſuch as are not acquainted with the nature of the machine, and in itſelf a pleaſing ſpectacle.

Every utenſil, however properly contrived to ſerve its purpoſe, requires ſome practice before it can be uſed adroitly. Put into the hands of a man, for the firſt time, a gimblet or a hammer (very ſimple inſtruments), and tell him the uſe of them, he ſhall neither bore a hole nor drive a nail with the dexterity or ſucceſs of another, who has been a little accuſtomed to handle them. The beginner therefore in the uſe of this machine, will do well not to be diſcouraged with little accidents that may ariſe at firſt from his want of experience. Being ſomewhat complex, it requires, as already ſaid, a variety of attentions; habit will render them unneceſſary; and the ſtudious man who is much in his chamber, and has a pleaſure in managing his own fire, will ſoon find this a machine moſt comfortable and delightful. To others who leave their fires to the care of ignorant ſervants, I do not recommend it. They will with difficulty acquire the knowledge neceſſary, and will make frequent blunders that will fill your room with ſmoke. It is therefore by no means fit for common uſe in families. It may be adviſable to begin with the flaming kind of ſtone coal, which is large, and, not caking together, is not ſo apt to clog the grate. After ſome experience, any kind of coal may be uſed, and with this advantage, that no ſmell, even from the moſt ſulphureous kind, can come into your room, the current of air being conſtantly into the vaſe, where too that ſmell is all conſumed.

The vaſe form was choſen as being elegant in itſelf, and very proper for burning of coals: where wood is the uſual fuel, and muſt be burnt in pieces of ſome length, a long ſquare cheſt may be ſubſtituted, in which *A* is the cover opening by a hinge behind, *B* the grate, *C* the hearth-box with its diviſions as in the other, *D* the plate or cover of the plan of the top of the cheſt, *E* the long narrow grate*. This I have not tried, but the vaſe machine was completed in 1771, and uſed by me in London three winters, and one afterwards in America, much to my ſatisfaction; and I have not yet thought of any improvement it may be capable of, though ſuch may occur to others. For common uſe, while in France, I have contrived another grate for coals, which has in part the ſame property of burning the ſmoke, and preſerving the red coals longer by the flame, though not ſo completely as in the vaſe, yet ſufficiently to be very uſeful, which I ſhall now deſcribe as follows:

A is a round grate, one foot (French) in diameter, and eight inches deep between the bars and the back; the ſides and back of plate iron; the ſides having holes of half an inch diameter, diſtant three or four inches from each other, to let in air for enlivening the fire †. The back without holes. The ſides do not meet at top

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* Plate II. Figure 17.

† Plate II. Fig. 18.

nor

nor at bottom by eight inches: that ſquare is filled by grates of ſmall bars croſſing front to back to let in air below, and let out the ſmoke or flame above. The three middle bars of the front grate are fixed; the upper and lower may be taken out and put in at pleaſure, when hot, with a pair of pincers. This round grate turns upon an axis, ſupported by the crotchet *B*, the ſtem of which is an inverted conical tube five inches deep, which comes on as many inches upon a pin that fits it, and which is fixed upright in a caſt iron plate *D*, that lies upon the hearth; in the middle of the top and bottom grates are fixed ſmall upright pieces *E E*, about an inch high, which, as the whole is turned on its axis, ſtop it when the grate is perpendicular. Figure 19 is another view of the ſame machine.

In making the firſt fire in a morning with this grate, there is nothing particular to be obſerved. It is made as in other grates, the coals being put in above, after taking out the upper bar, and replacing it when they are in. The round figure of the fire when thoroughly kindled is agreeable; it repreſents the great giver of warmth to our ſyſtem. As it burns down and leaves a vacancy above, which you would fill with freſh coals, the upper bar is to be taken out, and afterwards replaced. The freſh coals, while the grate continues in the ſame poſition, will throw up, as uſual, a body of thick ſmoke. But every one accuſtomed to coal fires in common grates, muſt have obſerved,

ſerved, that pieces of freſh coal ſtuck in below among the red coals, have their ſmoke ſo heated, as that it becomes flame as faſt as it is produced, which flame riſes among the coals, and enlivens the appearance of the fire. Here then is the uſe of this ſwivel grate. By a puſh with your tongs or poker, you turn it on its pin till it faces the back of the chimney, then turn it over on its axis gently till it again faces the room, whereby all the freſh coals will be found under the live coals, and the greater part of the ſmoke ariſing from the freſh coals will in its paſſage through the live ones be heated, ſo as to be converted into flame: whence you have much more heat from them, and your red coals are longer preſerved from conſuming. I conceive this conſtruction, though not ſo complete a conſumer of all the ſmoke as the vaſe, yet to be fitter for common uſe, and very advantageous. It gives too a full ſight of the fire, always a pleaſing object, which we have not in the other. It may with a touch be turned more or leſs from any one of the company that deſires to have leſs of its heat, or preſented full to one juſt come out of the cold. And ſupported in a horizontal poſition, a tea-kettle may be boiled on it.

The author's deſcription of his Pennſylvania fire-place, firſt publiſhed in 1744, having fallen into the hands of workmen in Europe, who did not, it ſeems, well comprehend the principles of that machine, it was much disfigured in their imitations of it; and one of its main intentions,

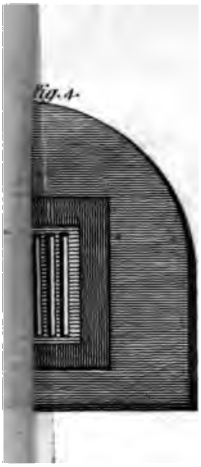
tentions, that of admitting a ſufficient quantity of freſh air warmed in entering through the air-box, nearly defeated, by a pretended improvement, in leſſening its paſſages to make more room for coals in a grate. On pretence of ſuch improvements, they obtained patents for the invention, and for a while made great profit by the ſale, till the public became ſenſible of that defect in the expected operation. If the ſame thing ſhould be attempted with this vaſe ſtove, it will be well for the buyer to examine thoroughly ſuch pretended improvements, leſt, being the mere productions of ignorance, they diminiſh or defeat the advantages of the machine, and produce inconvenience and diſappointment.

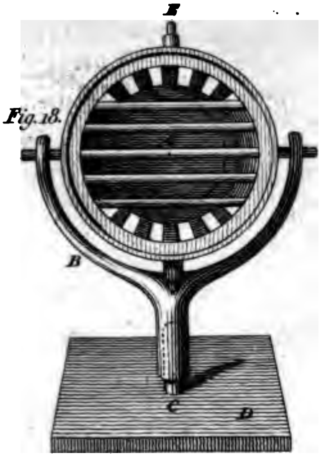
The method of burning ſmoke, by obliging it to deſcend through hot coals, may be of great uſe in heating the walls of a hot-houſe. In the common way, the horizontal paſſages or flues that are made to go and return in thoſe walls, loſe a great deal of their effect when they come to be foul with ſoot; for a thick blanket-like lining of ſoot prevents much of the hot air from touching and heating the brick-work in its paſſage, ſo that more fire muſt be made as the flue grows fouler: but by burning the ſmoke they are kept always clean. The ſame method may alſo be of great advantage to thoſe buſineſſes in which large coppers or caldrons are to be heated.

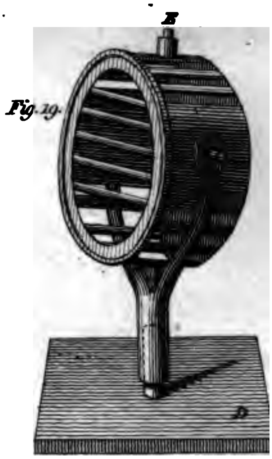
Written at Sea, 1785.

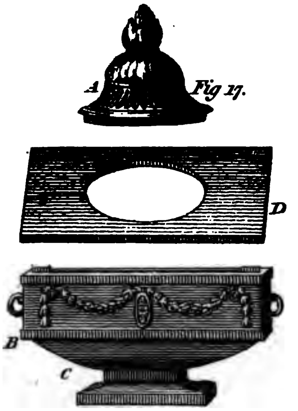
FINIS.

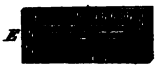
Pl

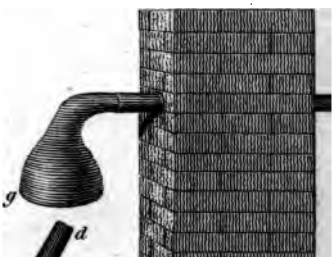


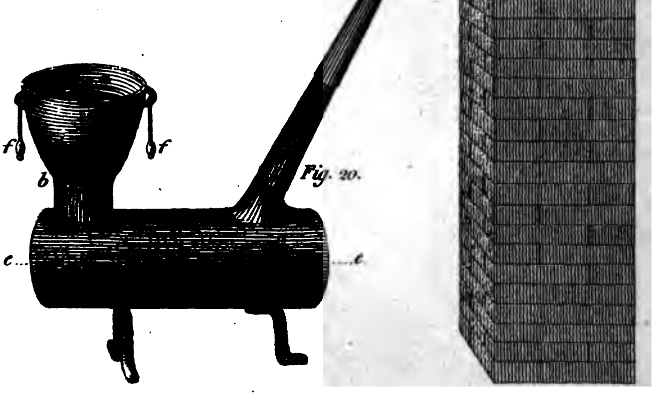


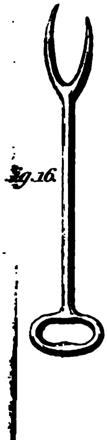












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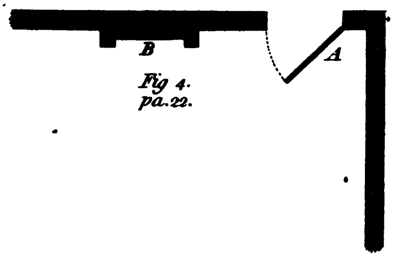
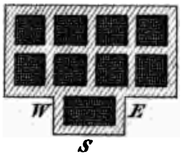


Fig 4.
pa. 22.

Fig. 12.
pa. 50.



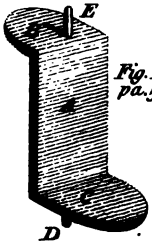


Fig. 13
pa. 50.

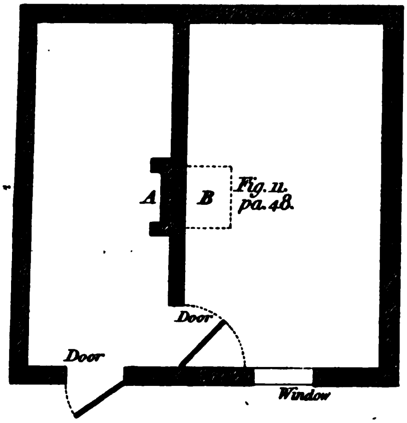


Fig. 11.
pa. 48.

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